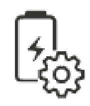
Richard Kawabe Tauscher

Vorstellung & Projekte

Inhalt

- Kenntnisse und Kompetenzen

Kenntnisse und Kompetenzen



BATTERIETECH. & LIB-PRODUKTION

Zellfertigung
Slurryherstellung & Coating
Zellenbau

Charakterisierung & Tests
Raten-Tests, mechano-physikalische und elektrochemische Methoden

Modellierung & Simulation
Alterungsmechanismen, Diffusionsmodelle, Kinetik, elektrochemische Parameteranalyse



PROGRAMMIERUNG & SIMULATION

Programmiersprachen (e-CF Level)
(2-3) MATLAB
(2) C++, Python
(1) HTML, XML, C#, VB

Modellierung & Simulation
1-D Modellierung, KMC Simulation, numerische Methoden, Datenanalyse

BMW-Industriepraktikum | Ziel/Aufgaben

Zielsetzung

- Untersuchung von durch Fremdfirmen hergestellter Elektroden
  - Gleiche chemische Zusammensetzung
  - Verschiedene Herstellungsprozesse
- Qualitätsbeurteilung durch schnelle und einfache Methoden

Aufgabe

- Methodenscreening geeigneter Prüfmethoden
- Korrelation mechano-physikalischer und elektrochemischer Eigenschaften

Aufgabengebiet

- Recherche von Prüfmethoden
- Kontaktherstellung zu Messfirmen
- Beauftragung von Fremdfirmen zu Materialprüfungen
- Probenpräparation
- Messmethode erstellen und verbessern
- Messungen an Proben
- Bau von funktionierenden Halb- und Vollzellen
- Auswertung von Messergebnissen

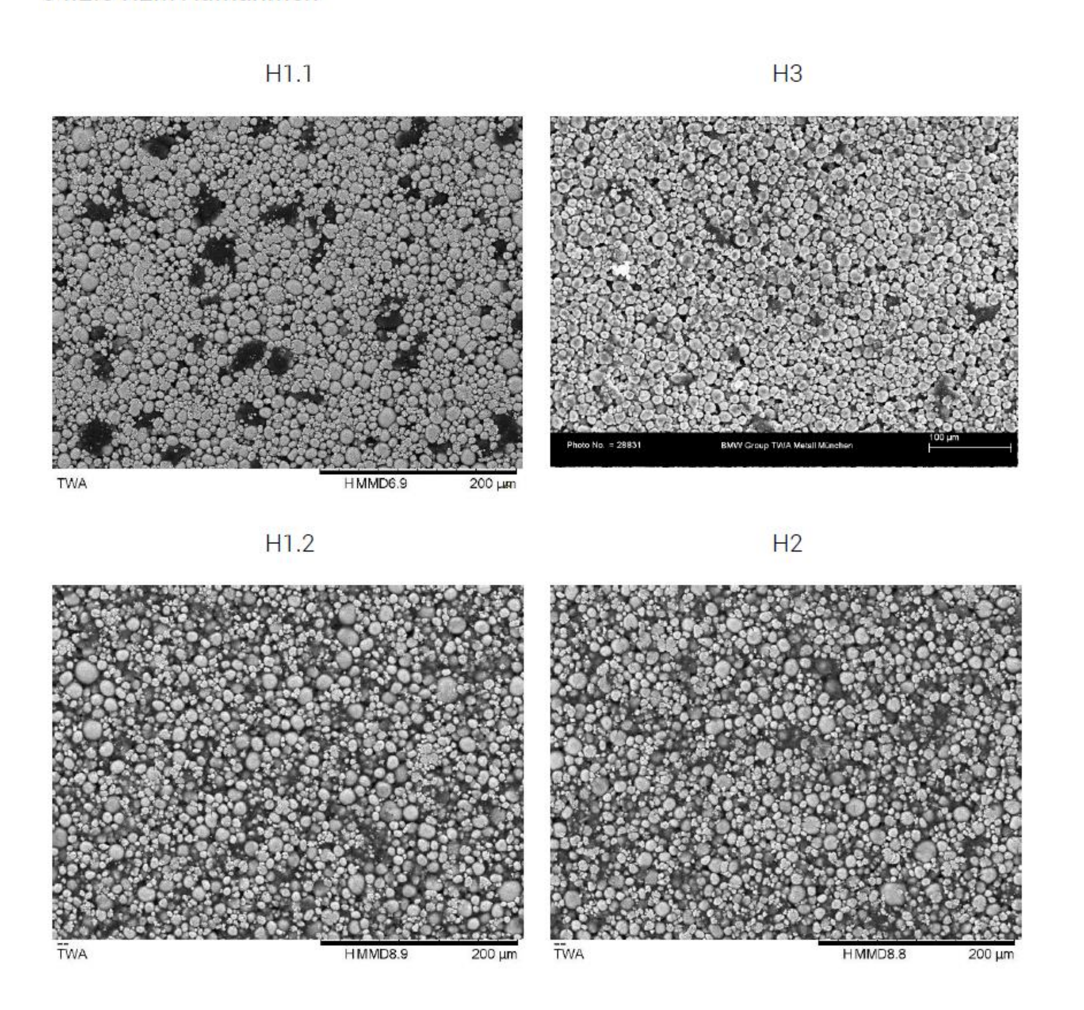
BMW-Industriepraktikum | Verfahren

Angewandte Verfahren

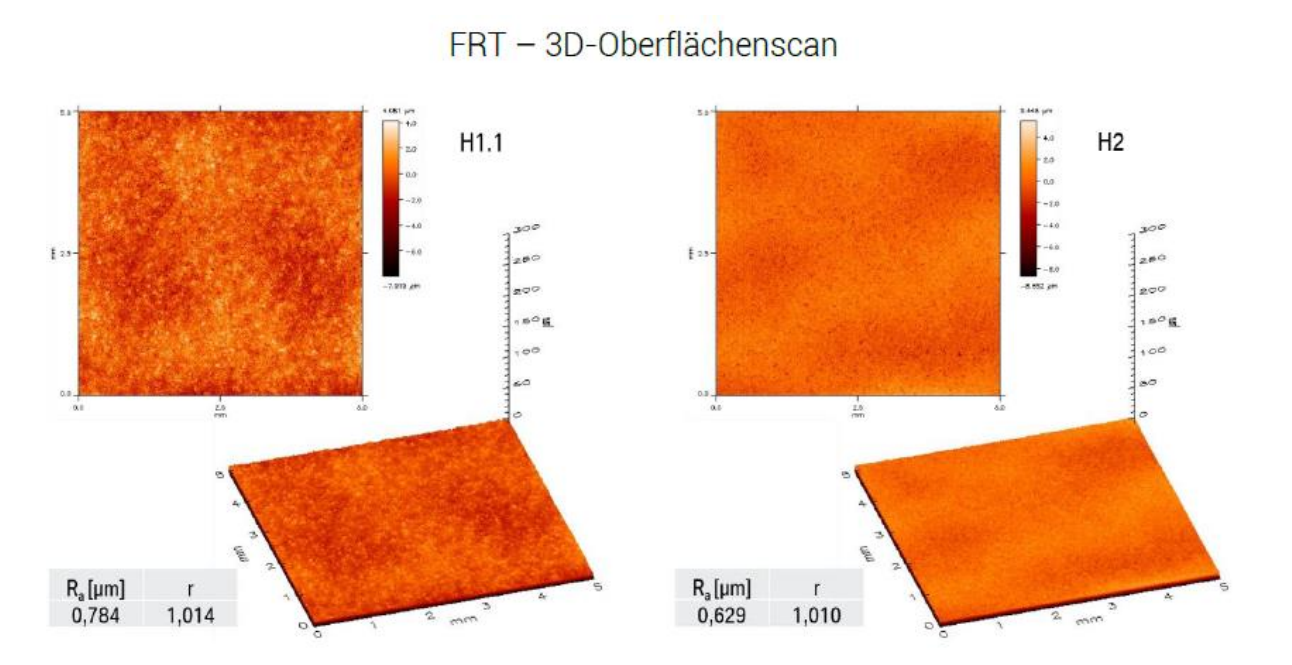
- Stirnzugprüfung
- Dornbiegeprüfung
- Massenverlustmessung
- Widerstandsmessung
- REM
- QCSM-Härteprüfung
- Durchstoß- / Berstprüfung
- Kontaktwinkelmessung
- 3D-Oberflächenscanning (FRT-Rauhigkeitsmessung)
- Elektrochemische Ratentests

BMW-Industriepraktikum | Ergebnisse

04.2.3 REM Aufnahmen



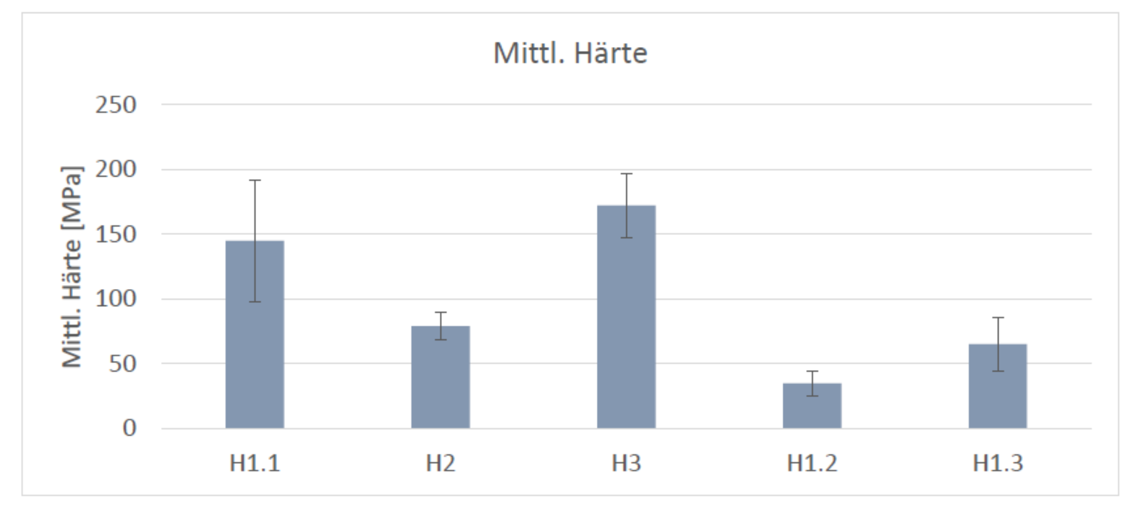
FRT – 3D-Oberflächenscan

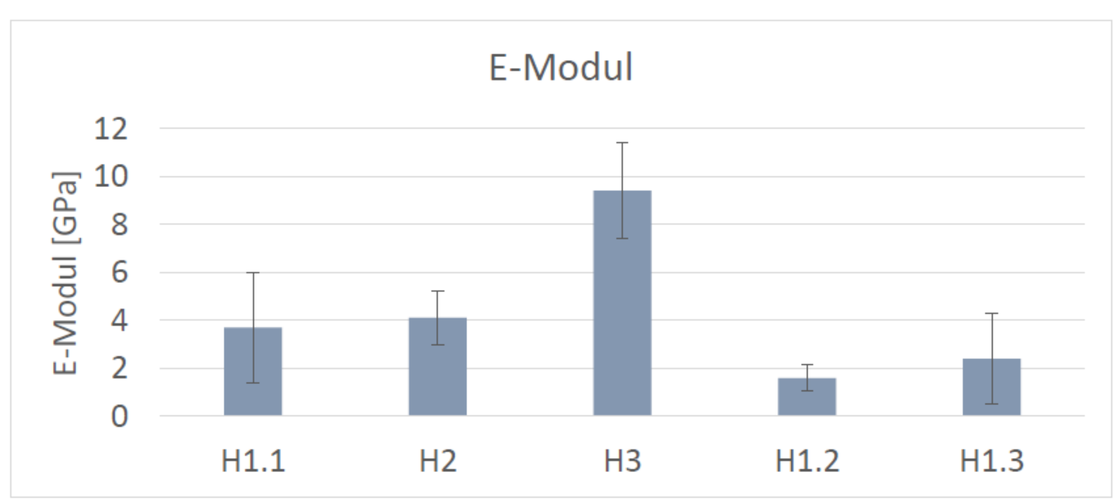


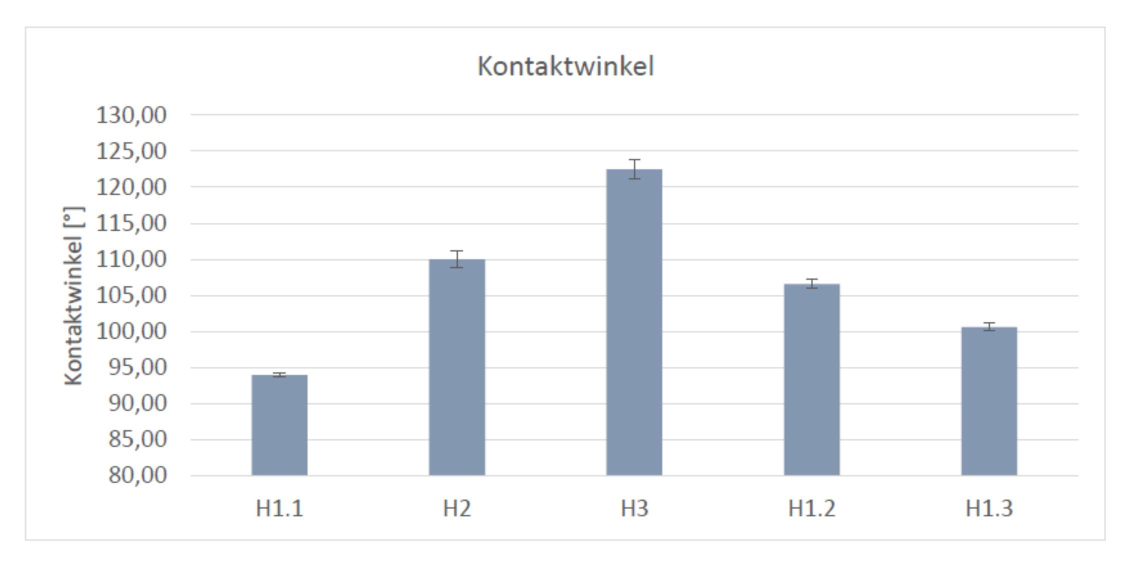
R_a [µm]	r
0,784	1,014

R_a [µm]	r
0,629	1,010

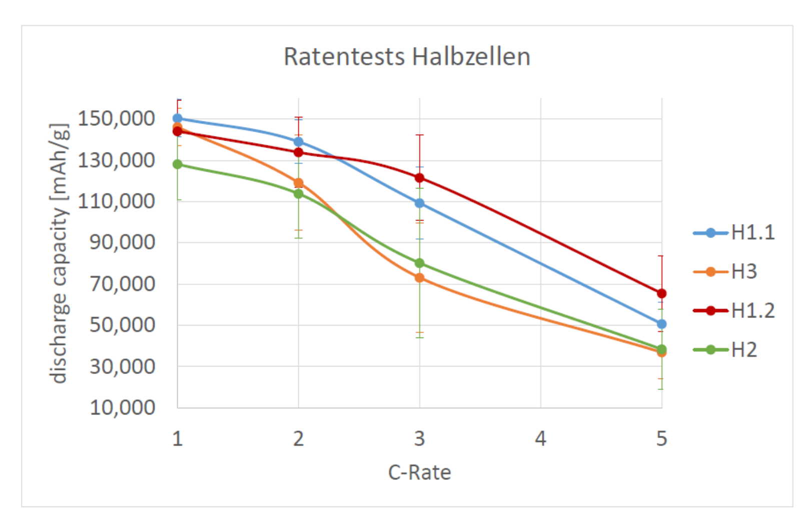
BMW-Industriepraktikum | Ergebnisse

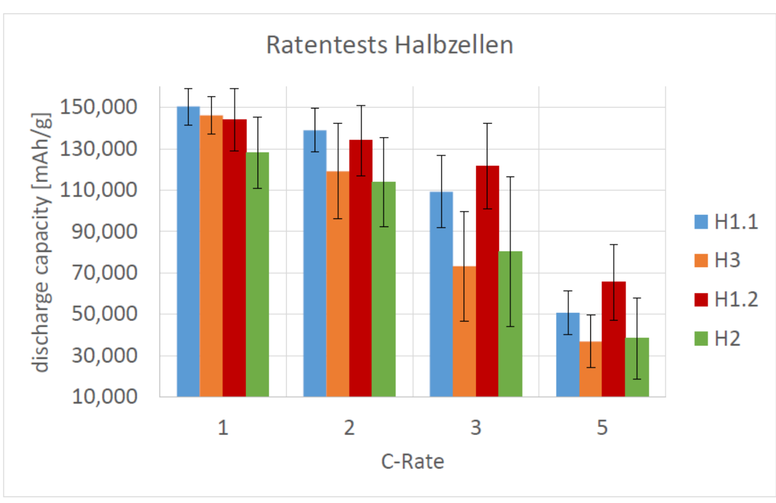






BMW-Industriepraktikum | Ergebnisse





Kathoden - Eigenschaften

200
180
160
140
120
100
80
60
40
20
0

Mittl. Härte [MPa]
Kontaktwinkel [°]
Widerstand [Ω*cm]
discharge capacity [mAh/g]

H1.1
H2
H3
H1.2
H1.3

BA Fraunhofer IPA | Ziel/Aufgaben

Zielsetzung

- Konzeption und Aufbau einer Anlage zur kontinuierlichen Pastenherstellung
    - Automatisierung und Digitalisierung
    - Inline-Charakterisierung des Produktes
- Untersuchung der Prozessparameter
    - Korrelation zwischen Prozessparameter und Pastenqualität

Aufgabe

- Konzeption und Aufbau der Anlage
- Optimierung und Fehlerbehebung
- Testreihen mit statistischer Versuchsplanung (DoE)

Aufgabengebiet

- Berechnungen zu Strömen und Drücken
- Aufbau der Anlage
- Unterstützung der Gefährdungsbeurteilungen
- Überprüfung Sensoren/Schutzeinrichtungen
- Erstellung von Betriebsanweisungen
- Beschaffung von Ausrüstung (inkl. PSA)
- Kalibrierung Messgeräte
- Validierung Messungen
- Versuchsdurchführung mit DoE
- Konzeption digitale Produktionstelle

BA Fraunhofer IPA | Aufbau



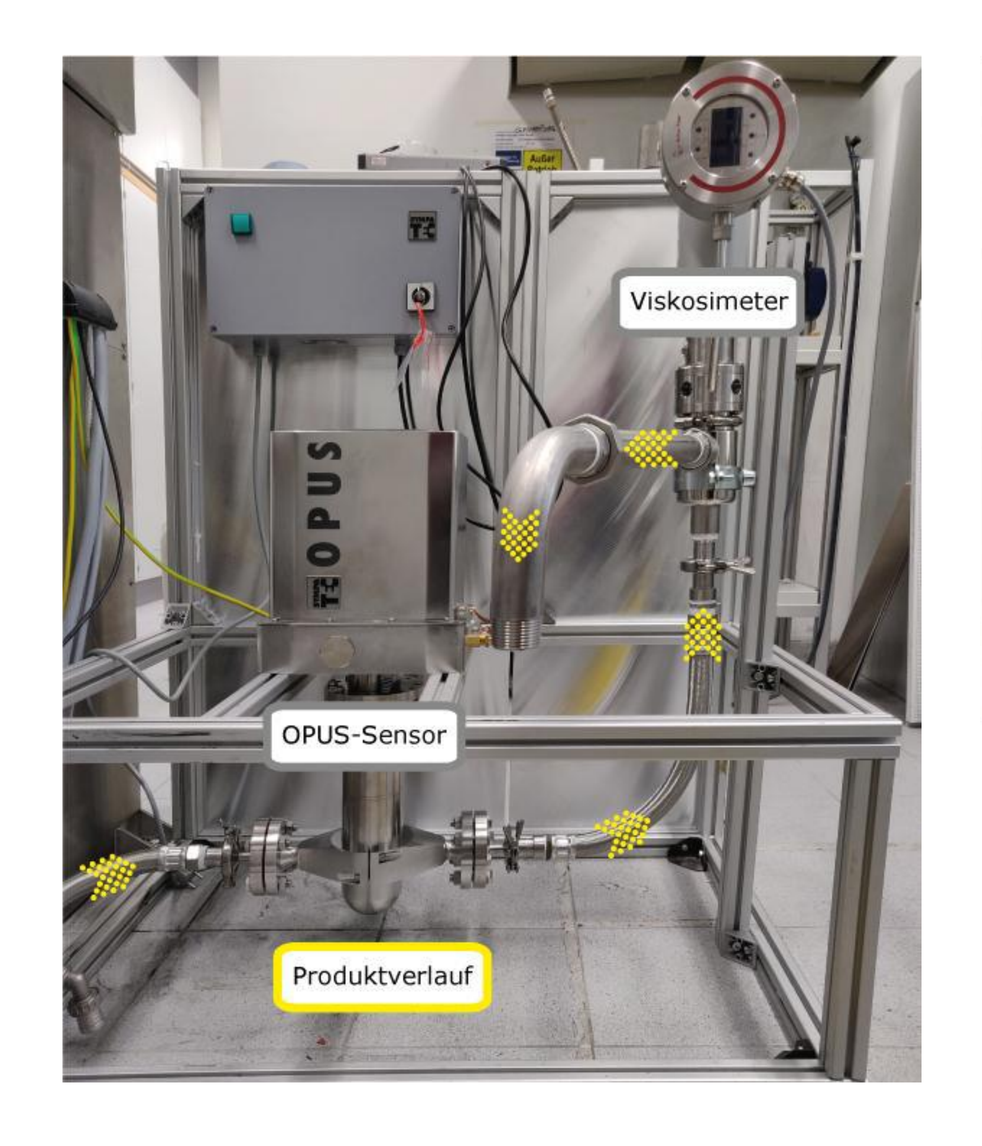


BA Fraunhofer IPA | Aufbau



Mischzone
Wärmeübertrager
Kühlleitungen
Temp.-Sensor

BA Fraunhofer IPA | Aufbau

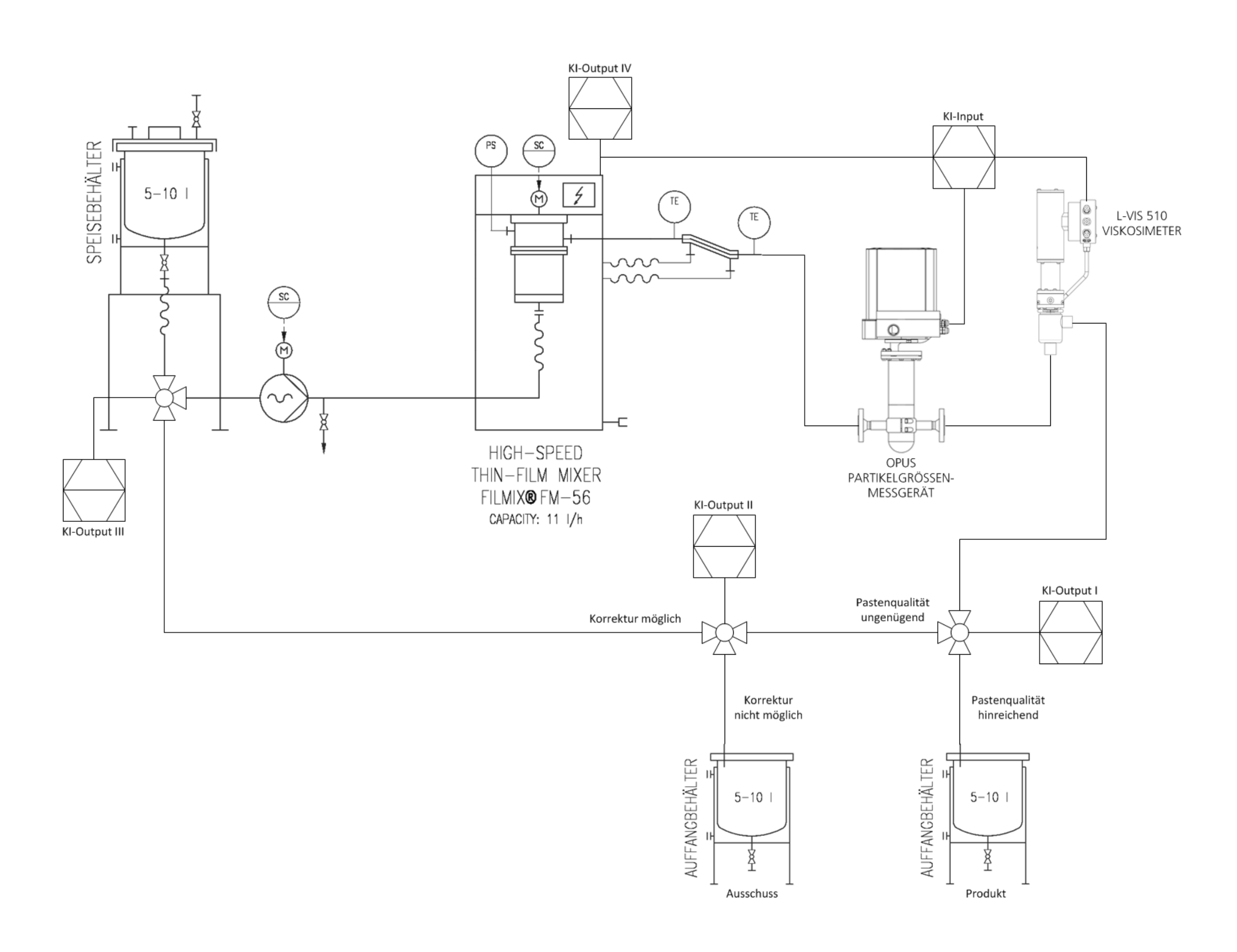




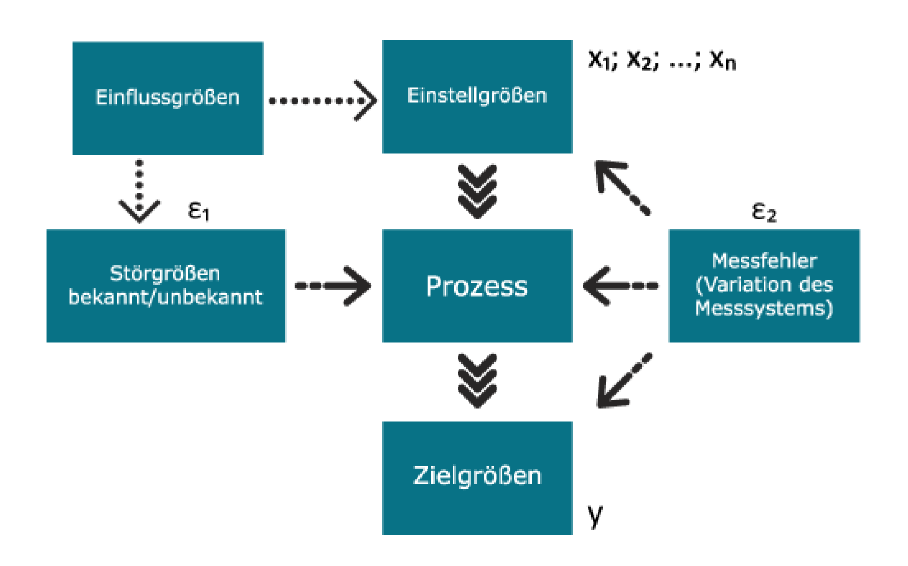


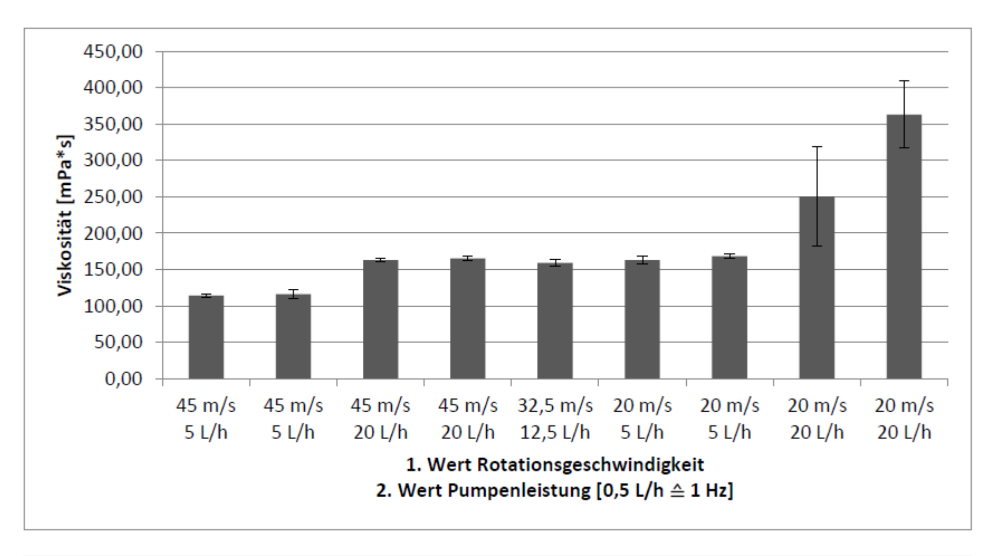


BA Fraunhofer IPA | Produktionszelle

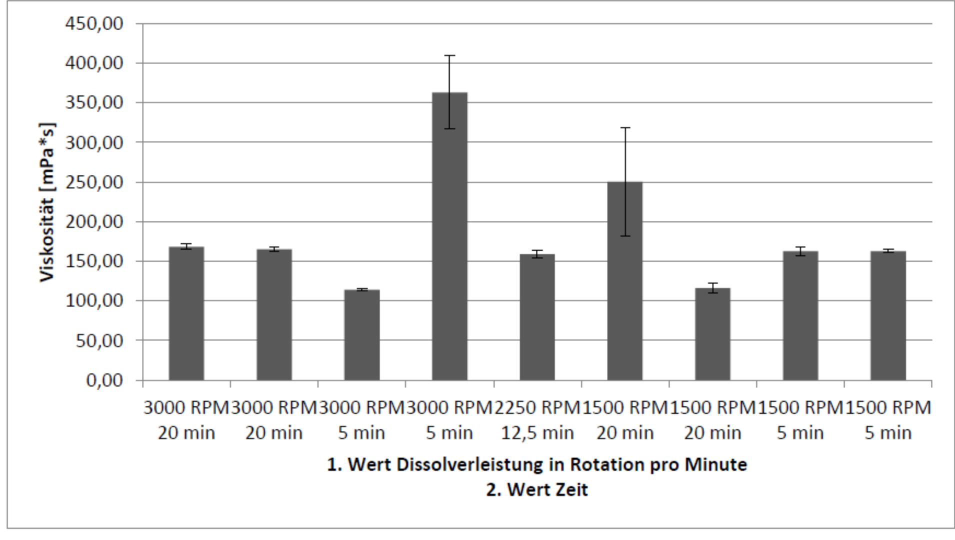


BA Fraunhofer IPA | DoE

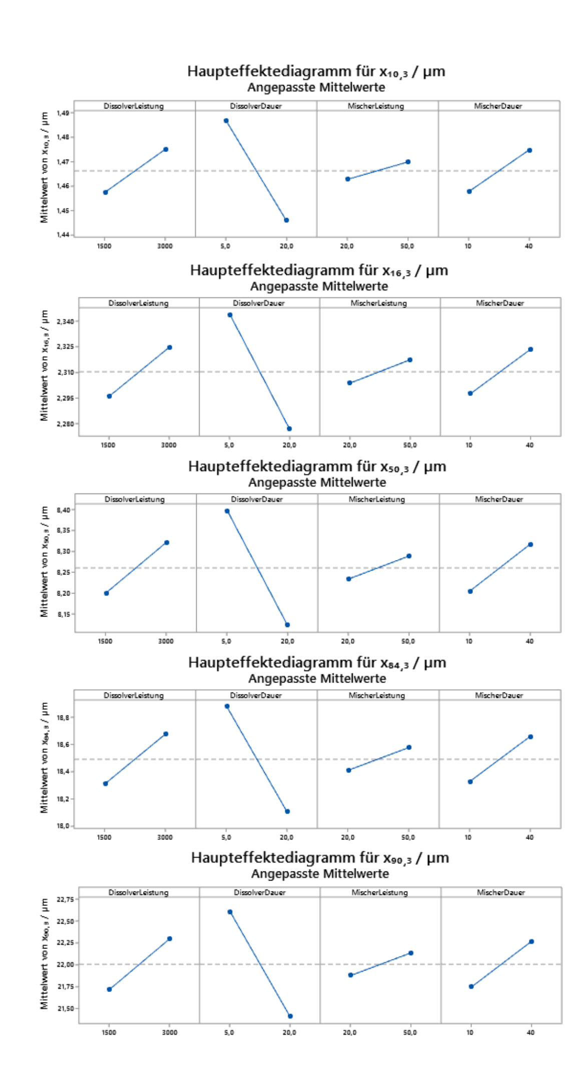




	Dissolver		Filmix	
RunOrder	Leistung	Dauer	Rotorgeschw.	Verweildauer
	[rpm]	[min]	[m/s]	[Hz]
1	3000	5	45	10
2	1500	5	20	10
3	1500	20	20	40
4	1500	20	45	10
5	3000	20	20	10
6	2250	12,5	32,5	25
7	1500	5	45	40
8	3000	5	20	40
9	3000	20	45	40



BA Fraunhofer IPA | Ergebnisse



MA KIT: IAM-ET | Ziel/Aufgaben

Zielsetzung

- Elektrochemische Modellierung der SEI Degradation bei thermischer Alterung

Aufgabe

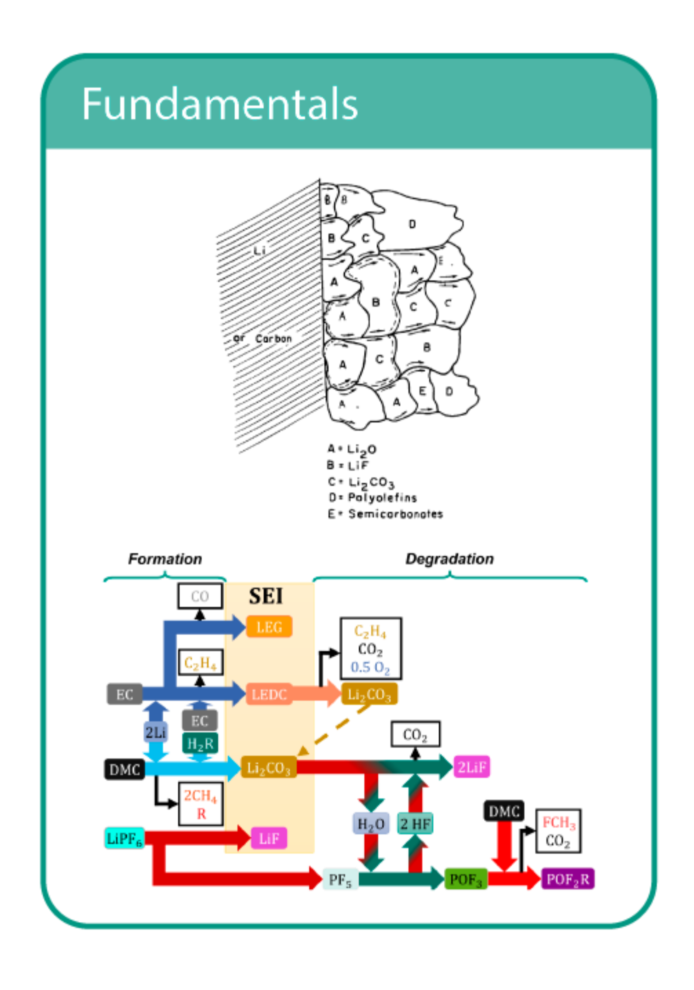
- Simulation einer Batteriezelle
- Modelle für SEI Abbildung und ablaufende chemisch-physikalische Prozesse
- Implementierung eines Reaktionsnetzwerks
- Parametereinstellung mithilfe OEMS-Prüfstand

Aufgabengebiet

- Theorie für Modellierung von Batteriesystemen
- Programmierung von
    - Simulationsbereich
    - Temperaturverläufe
    - SoC-Initiierung
    - Diffusion
    - Volumensänderung
- Datenanalyse und -Abgleich

Contents

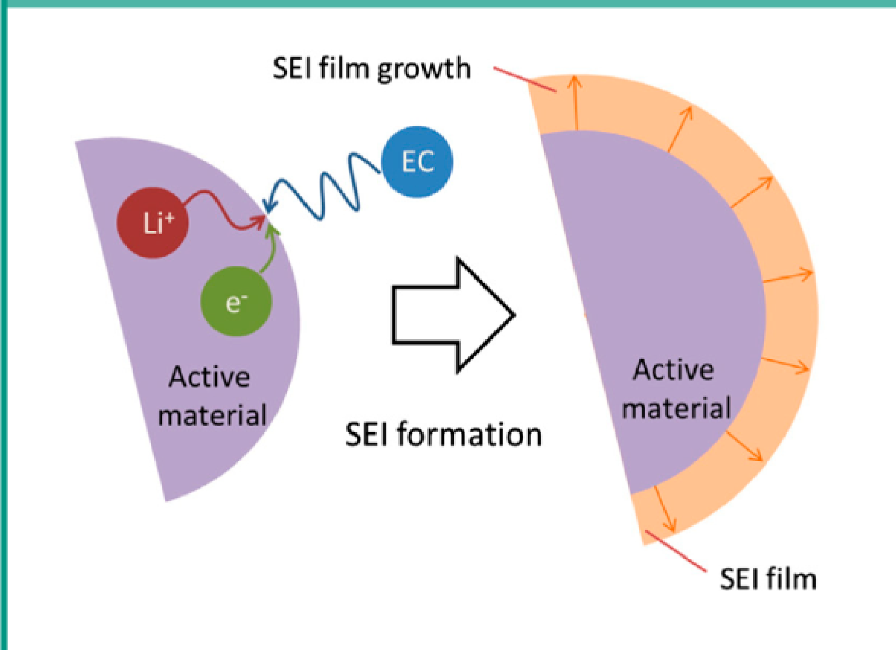

Karlsruhe Institute of Technology


Fundamentals
Li
or Carbon
A = Li2O
B = LiF
C = Li2CO3
D = Polyolefins
E = Semicarbonates
Formation
Degradation
SEI
CO
LEG
C2H4
EC
LEDC
Li2CO3
C2H4
CO2
0.5 O2
2Li
EC
H2R
DMC
Li2CO3
CO2
2LiF
2CH4
R
LiPF6
LiF
H2O
2 HF
DMC
FCH3
CO2
PF5
POF3
POF2R

Fundamentals - SEI

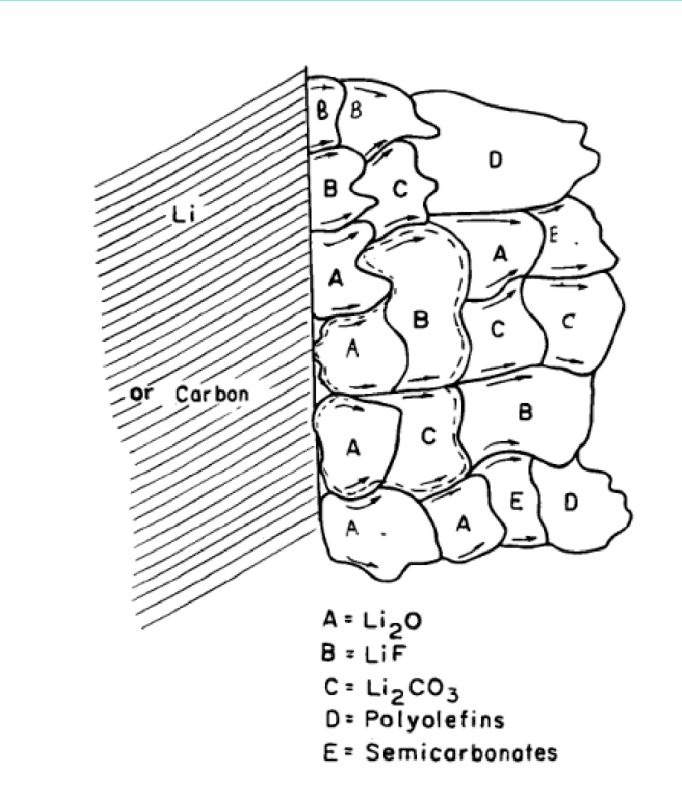


Solid Electrolyte Interphase - Formation



- SEI Formation during cycling
- Composition depends on materials

SEI Species and Properties



- Inner anorganic layer
  - Li_2O
  - LiF
  - Li_2CO_3
- Outer organic layer
  - LEDC
  - Li_2CO_3
- Higher porosity on outer layer
- Isolating properties
- SEI has stabilizing properties

Fundamentals - Reactions



SEI Formation Reactions

$$EC + 2\,e^- + 2\,Li^+ \rightleftharpoons Li_2CO_3 + C_2H_{4(g)}$$

$$2\,EC + 2\,e^- + 2\,Li^+ \rightleftharpoons LEDC + C_2H_{4(g)}$$

$$0.5\,O_2 + e^- + Li^+ \rightleftharpoons Li_2O$$

$$LiPF_{6(s)} \rightleftharpoons LiF_{(s)} + PF_5$$

- Mostly reactions with Lithium
- Mainly on first cycling

SEI Degradation Reactions

$$LEDC \rightleftharpoons Li_2CO_3 + C_2H_{4(g)} + CO_{2(g)} + 0.5\,O_{2(g)}$$

$$Li_2CO_3 + 2\,HF \rightleftharpoons 2\,LiF_{(s)} + CO_{2(g)} + H_2O_{(l)}$$

- High gaseous species output
- Hydroflouric acid can lead to high degration

Salt Decomposition Reactions

$$LiPF_{6(s)} \rightleftharpoons LiF_{(s)} + PF_5$$

$$PF_5 + H_2O_{(l)} \rightleftharpoons POF_3 + 2\,HF$$

$$POF_3 + H_2O_{(l)} \rightleftharpoons POF_2OH + 2\,HF$$

$$POF_3 + DMC \rightleftharpoons POF_2OCH_3 + FCH_{3(g)} + CO_{2(g)}$$

- Contamination of cell with water leads to hydroflouric acid production
- Formation of phosphorus oxyfluoride derivates

(Electro-)Chemical Reactions



Formation

Degradation

SEI

CO

LEG

C_2H_4

EC

LEDC

C_2H_4
CO_2
$0.5\ O_2$

Li_2CO_3

2Li

EC

H_2R

DMC

Li_2CO_3

CO_2

2LiF

$2CH_4$
R

H_2O

2 HF

DMC

FCH_3
CO_2

$LiPF_6$

LiF

PF_5

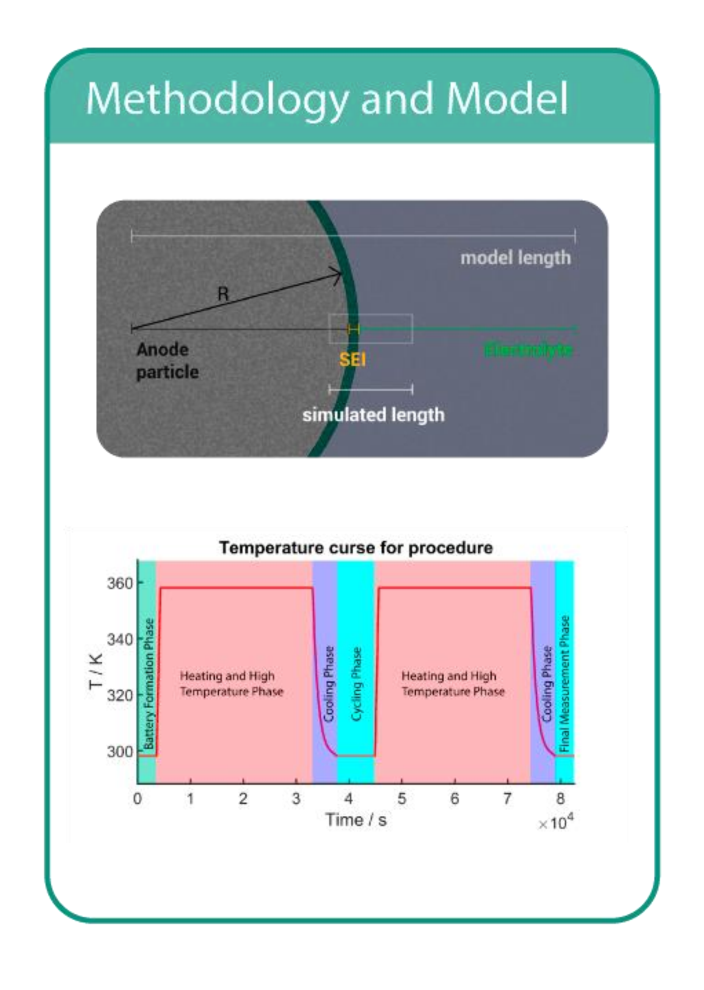
POF_3

POF_2R

Contents



Karlsruhe Institute of Technology



Methodology and Model
model length
R
Anode
particle
SEI
simulated length
Temperature curse for procedure
360
340
320
300
T / K
Battery Formation Phase
Heating and High Temperature Phase
Cooling Phase
Cycling Phase
Heating and High Temperature Phase
Cooling Phase
Final Measurement Phase
0
1
2
3
4
5
6
7
8
Time / s
×10^4

Simulation Structure

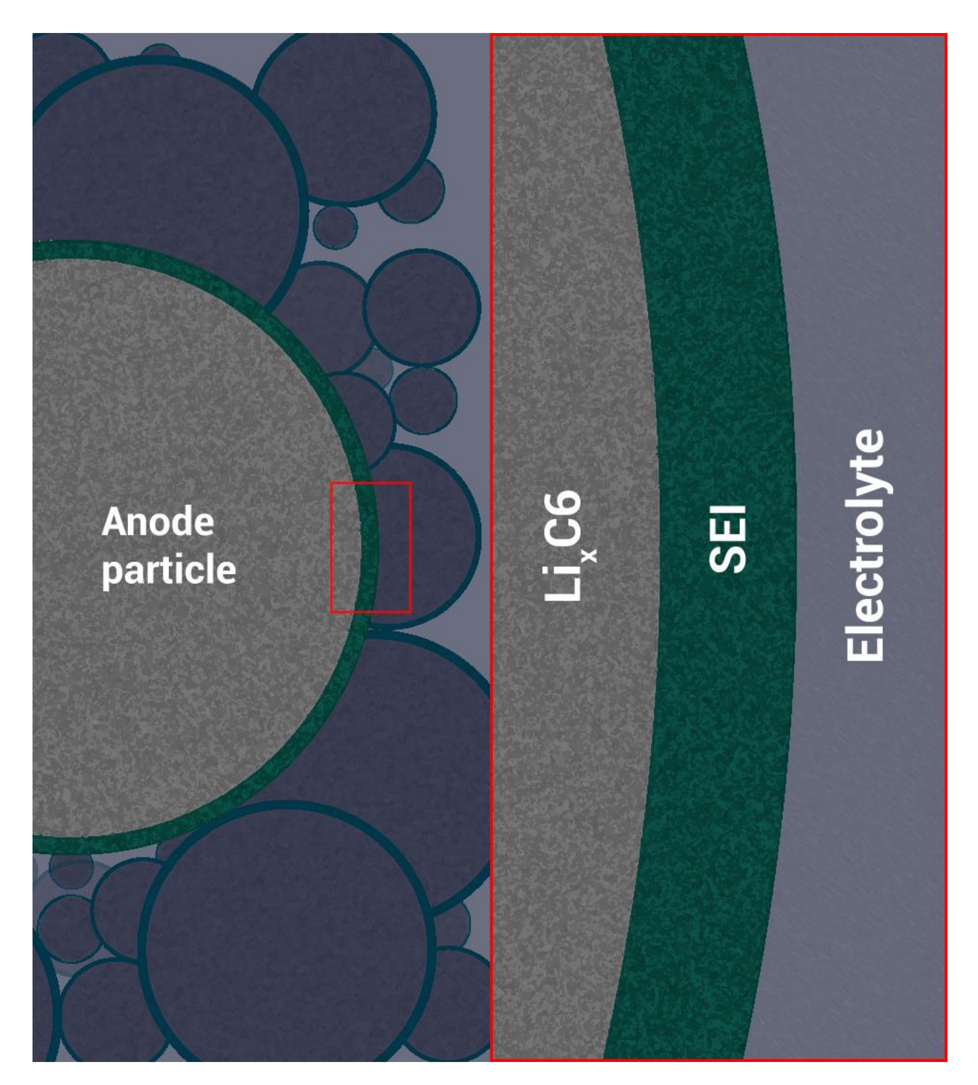


Simulation Basis: Experimental Setup

- OEMS (on-line electrochemical mass spectrometry)
- Measurement procedure with heating process

Model basis: Single Particle Model

- Electrode represented by single particle
- Chemical reactions accounting for solid SEI species, electrolyte and gases
- Mass transport via diffusion



Characteristics – Model and Simulation Area



Model Parameters

Model length defined by:

- Equal length anode and electrolyte
- SEI thickness

Simulation Characteristics

Simulation length

- Computational restrictions
- Shorter than model length
- SEI fully simulated

model length
R
Anode particle
SEI
Electrolyte
simulated length

Characteristics – Diffusion Model



Diffusion - Fick's 2nd law

$$\frac{\partial c_{\mathrm{a}}}{\partial t} = D_{\mathrm{a}} \frac{\partial^2 c_{\mathrm{a}}}{\partial x^2}$$

Model Assumptions

- Three main areas
- Defined volume elements (VE)
- Diffusion between VEs
- Diffusion restricted between anode and SEI area
- Outside sim area: bulk
- Diff. only by fluid species

Li^+

$LiPF_6$
EC
DMC

diffusion inside simulated area

Li_xC_6 bulk

Anode particle

SEI

Electrolyte

Electr. bulk

simulated length

Parameters for Species



Initial Concentration

SEI species

- Bisection method
- x = 0 nm
  - 0% porosity
  - 100% LiF/Li_2O
  - 0% LEDC
- x = 50 nm
  - 100% porosity
  - 0% LiF/Li_2O
  - 100% LEDC
- Li_2CO_3 max. volume in between

Electrolyte

- 1:1 EC/DMC
- 1M $LiPF_6$
- 50 ppm H_2O

Anode particle

- Total volume Li_xC_6

Anode particle
SEI
Δx = 50 nm
Electrolyte

LEDC — Li_2CO_3 — Li_2O — LiF — $LiPF_6$ — DMC — EC

Characteristics – Dynamic Volume Model



Anode particle | SEI | Electrolyte

x

LEDC — Li_2CO_3 — Li_2O — LiF — $LiPF_6$ — DMC — EC

Model assumption

- Reactions and diffusion lead to changes in volume
- Volume change of VEs adapt dynamically

Implementation

$$x_{\mathrm{dyn}}(t) = \frac{V_{\mathrm{VE,dyn}}}{A_{\mathrm{VE}}}$$

$$\frac{\partial c_{\mathrm{a}}}{\partial t} = D_{\mathrm{a}} \frac{\partial^2 c_{\mathrm{a}}}{\partial {x_{\mathrm{dyn}}}^2}$$

Experimental Procedure



T / K
360
340
320
300
0 1 2 3 4 5 6 7 8
Time / s
$\times 10^4$
Battery Formation Phase
Heating and High Temperature Phase
Cooling Phase
Cycling Phase
Heating and High Temperature Phase
Cooling Phase
Final Measurement Phase

Procedure

- Battery formation
- Two heating periods w/ measurements
- Cycling phase
- Final measurement

Cell specification

- Lithium ion battery
- $LiCoO_2$ cathode
- Graphite anode

Simulation Procedure



Procedure 1 & 2

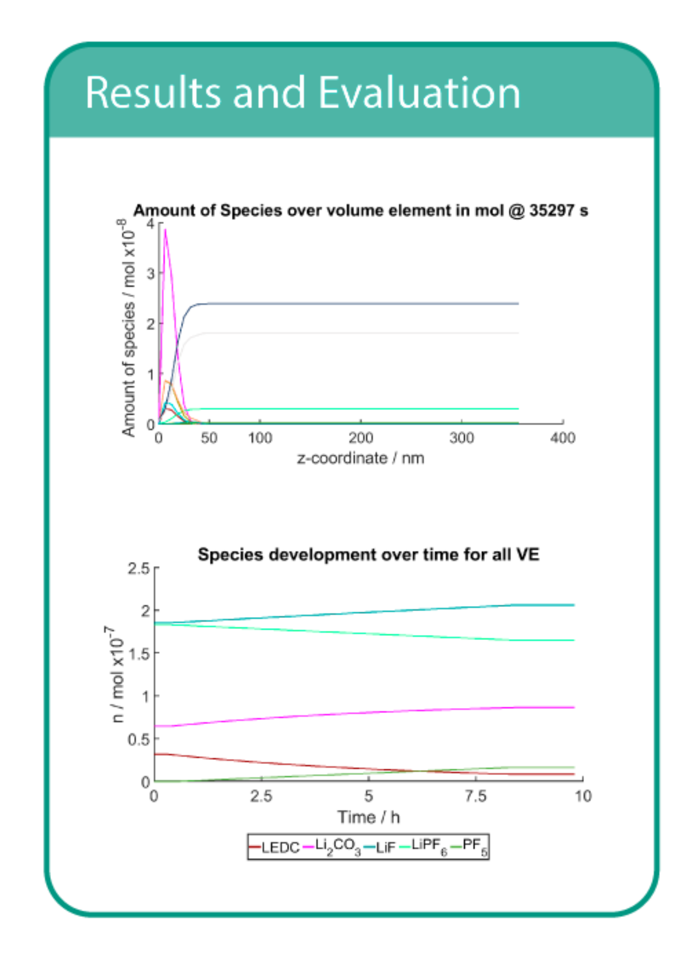
- t = 4000 s (~1.25 h)
- T_0 = 25°C
- $T_{max,1}$ = 25°C
- $T_{max,2}$ = 85°C
- Heating rate = 0.083 K/s

Procedure 3

- t = 37697 s (~10.5 h)
- T_0 = 25°C
- T_{max} = 85°C
- Heating rate = 0.083 K/s

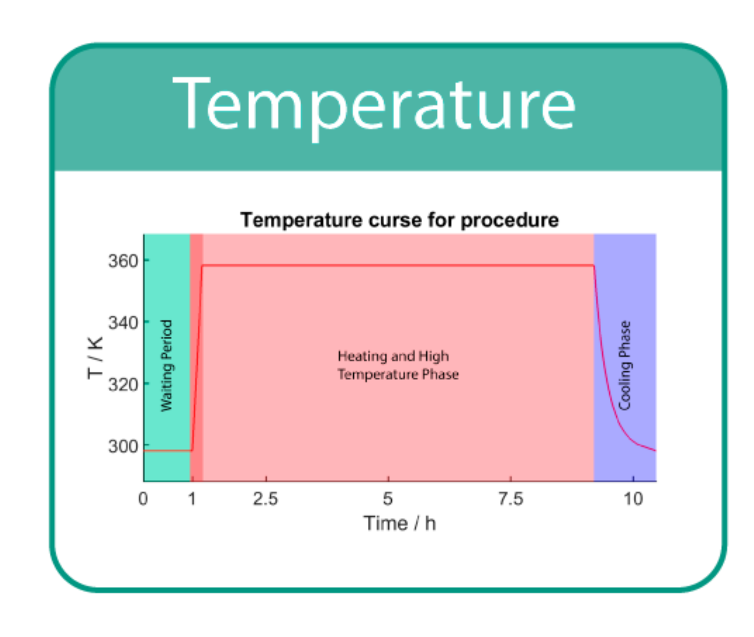
Contents


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Results and Evaluation
Amount of Species over volume element in mol @ 35297 s
Amount of species / mol x10-8
z-coordinate / nm
Species development over time for all VE
n / mol x10-7
Time / h
LEDC
Li2CO3
LiF
LiPF6
PF5

Evaluation and Results





Temperature Dependency



End Amount of Species

Differential Amount of Species

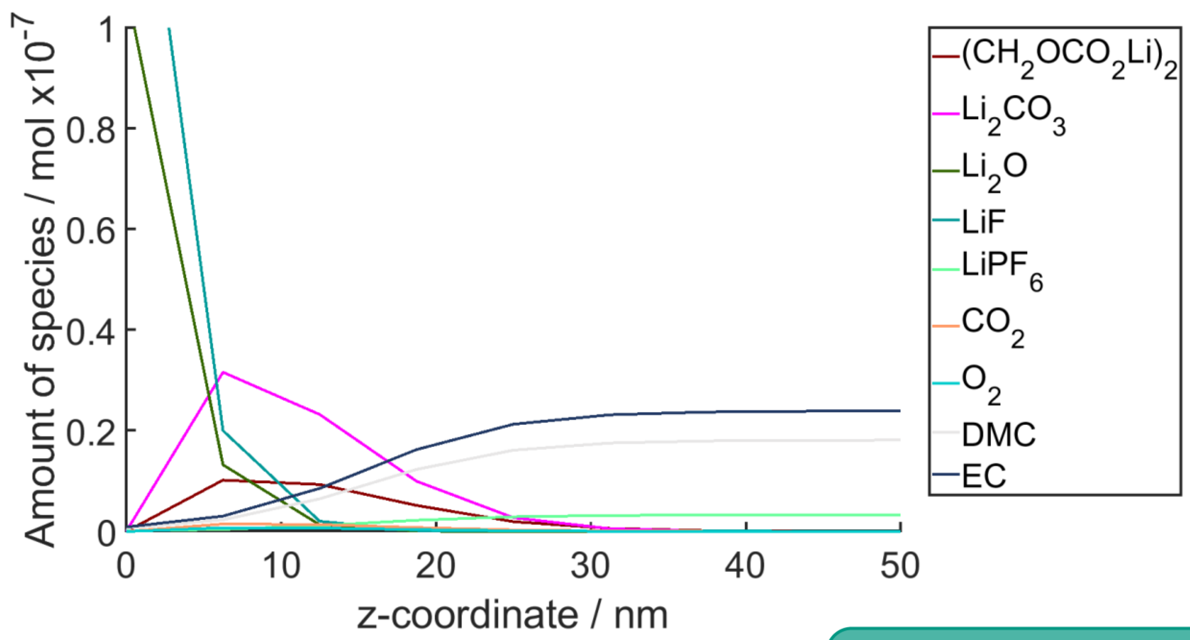
T = 25°C - Influence on reactions

- Reaction rates low
- Differential changes at 10^{-17}

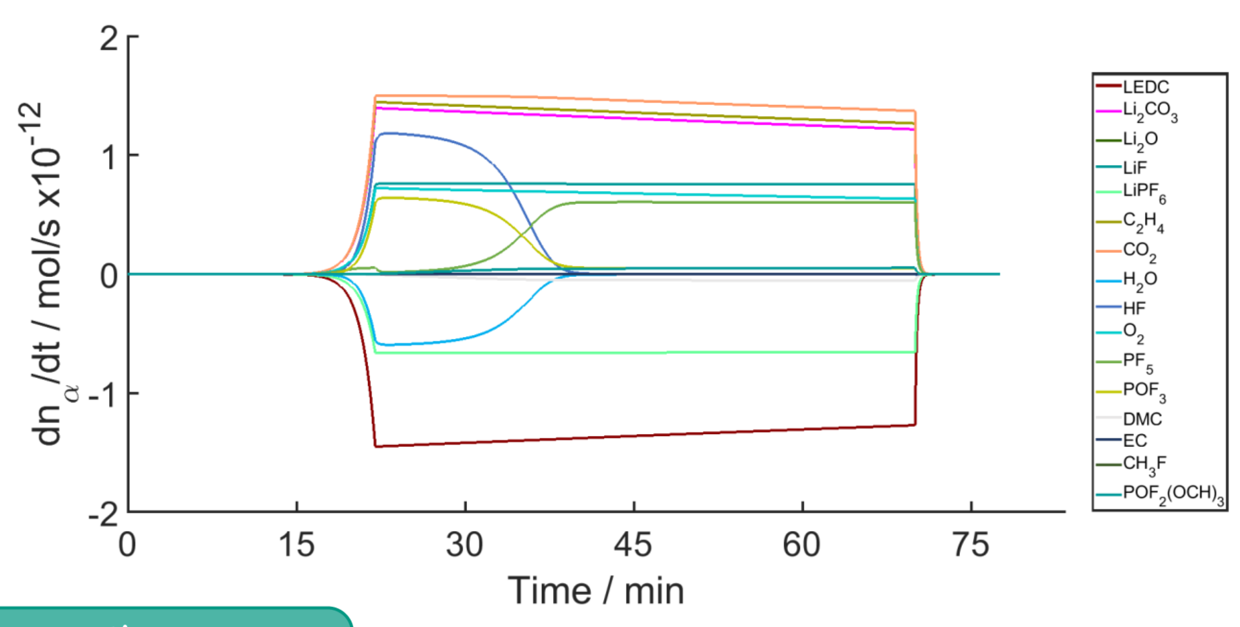
Temperature Dependency







Differential Amount of Species



T = 85°C - Influence on reactions

- Reaction rates higher
- Differential changes at 10^{-12}

Temperature - Reactions



dn_{α}/dt / mol/s x10^{-12}

2
1.5
1
5
0
-0.5
-1

15
30
45

Time / min

LiF
$LiPF_6$
CO_2
H_2O
HF
PF_5
POF_3
DMC
CH_3F
$POF_2(OCH)_3$

$LiPF_6$ Decomposition

$$LiPF_{6(s)} \rightleftharpoons LiF_{(s)} + PF_5$$

PF_5 / POF_3 Decomp. | HF Formation

$$PF_5 + H_2O_{(l)} \rightleftharpoons POF_3 + 2\,HF$$

$$POF_3 + H_2O_{(l)} \rightleftharpoons POF_2OH + 2\,HF$$

Li_2CO_3 Degradation with HF

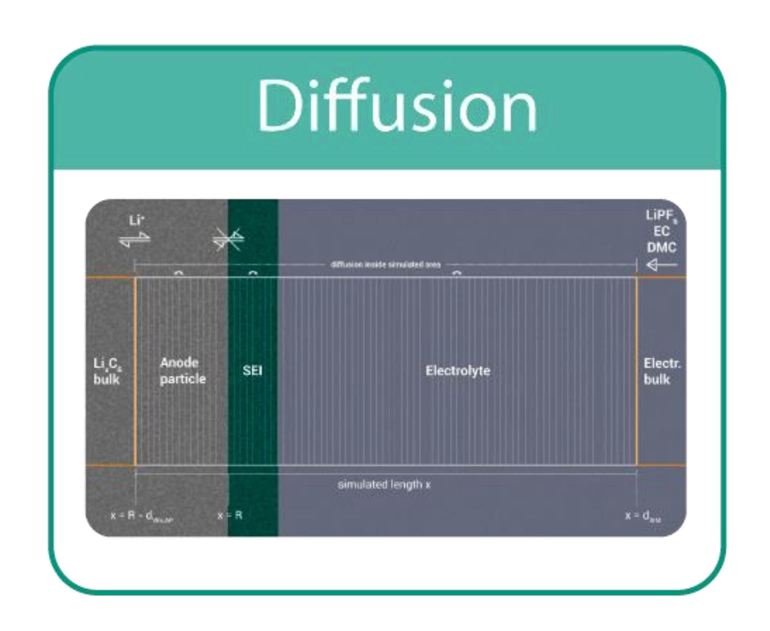
$$Li_2\,CO_3 + 2\,HF \rightleftharpoons 2\,LiF_{(s)} + CO_{2(g)} + H_2O_{(l)}$$

POF_3 Degradation with DMC

$$POF_3 + DMC \rightleftharpoons POF_2OCH_3 + FCH_{3(g)} + CO_{2(g)}$$

Evaluation and Results





Diffusion – Impact on Simulation



Diffusion off

n / mol x10^{-7}

0 0.5 1 1.5 2

0 2.5 5 7.5 10

Time / h

Diffusion on

n / mol x10^{-7}

0 0.5 1 1.5 2

1 2.5 5 7.5 10

Time / h

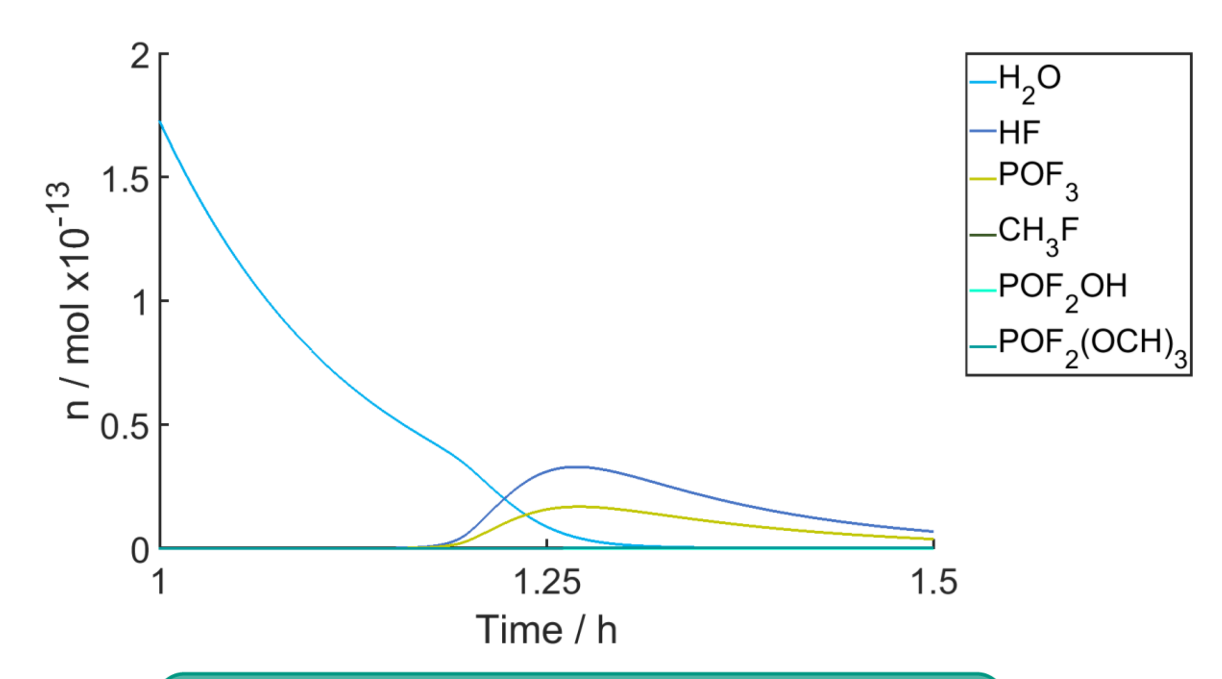
LEDC, Li_2CO_3, LiF, $LiPF_6$, PF_5

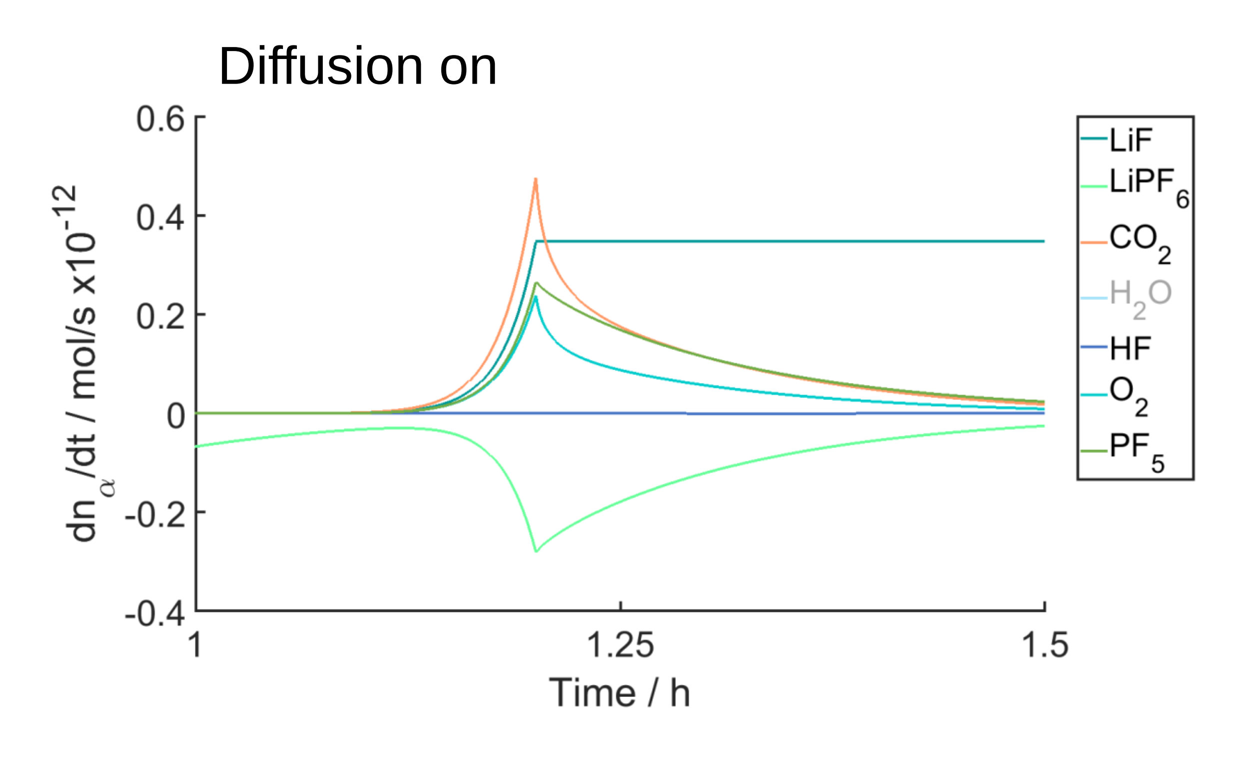
Diffusion Impact

- No impact on SEI species LEDC, Li_2CO_3, LiF
- Major impact on electrolyte species

Diffusion – Heating Phase







Diffusion Impact

- Active decrease in electrolyte species concentration
- Shortage on water inhibits all further electrolyte reactions

Li_2CO_3 Degradation with HF

$$Li_2CO_3 + 2\,HF \rightleftharpoons 2\,LiF_{(s)} + CO_{2(g)} + H_2O_{(l)}$$

PF_5 / POF_3 Decomp. | HF Formation

$$PF_5 + H_2O_{(l)} \rightleftharpoons POF_3 + 2\,HF$$

$$POF_3 + H_2O_{(l)} \rightleftharpoons POF_2OH + 2\,HF$$

Diffusion – Cooling Phase



Diffusion off

0.75
0.5
0.25
0
-0.25
-0.5
-0.75

dn_α/dt / mol/s x10^{-12}

8.25
8.5
8.75

Time / h

LiF
$LiPF_6$
CO_2
H_2O
HF
PF_5
POF_3
DMC
CH_3F
$POF_2(OCH)_3$

Diffusion on

0.5
0
-0.5

dn_α/dt / mol/s x10^{-12}

9
9.5
10

Time / h

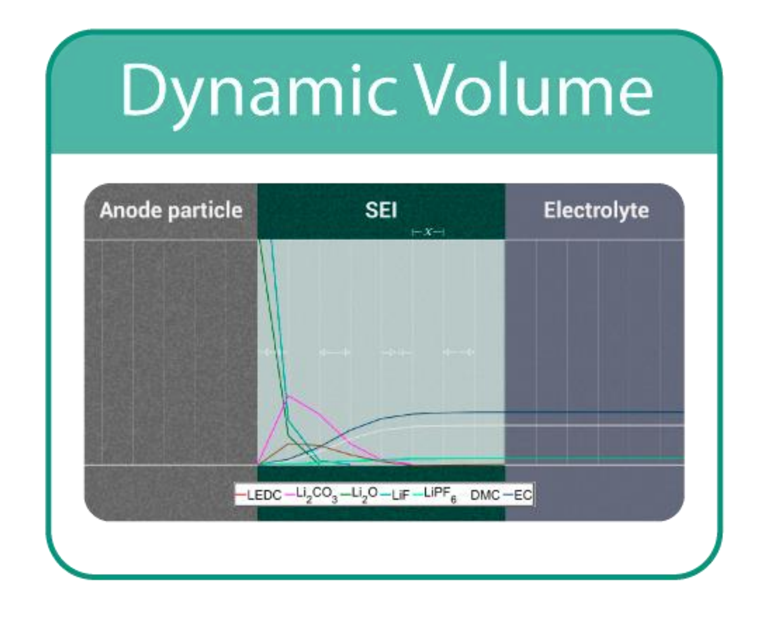
LEDC
Li_2CO_3
LiF
$LiPF_6$
C_2H_4
CO_2
H_2O
HF
O_2
PF_5

Diffusion Impact

- Due to temperature drop, reactions are inhibited
- $LiPF_6$ from bulk flowing in
- Active decrease in concentration

Evaluation and Results





Dynamic Volume – Impact on Simulation



Static Volume

dn_α/dt / mol/s x10^{-12}

Time / h

Legend: LiF, $LiPF_6$, CO_2, H_2O, HF, O_2, PF_5

Dynamic Volume

dn_α/dt / mol/s x10^{-12}

Time / h

Legend: LiF, $LiPF_6$, C_2H_4, CO_2, H_2O, HF, O_2, PF_5

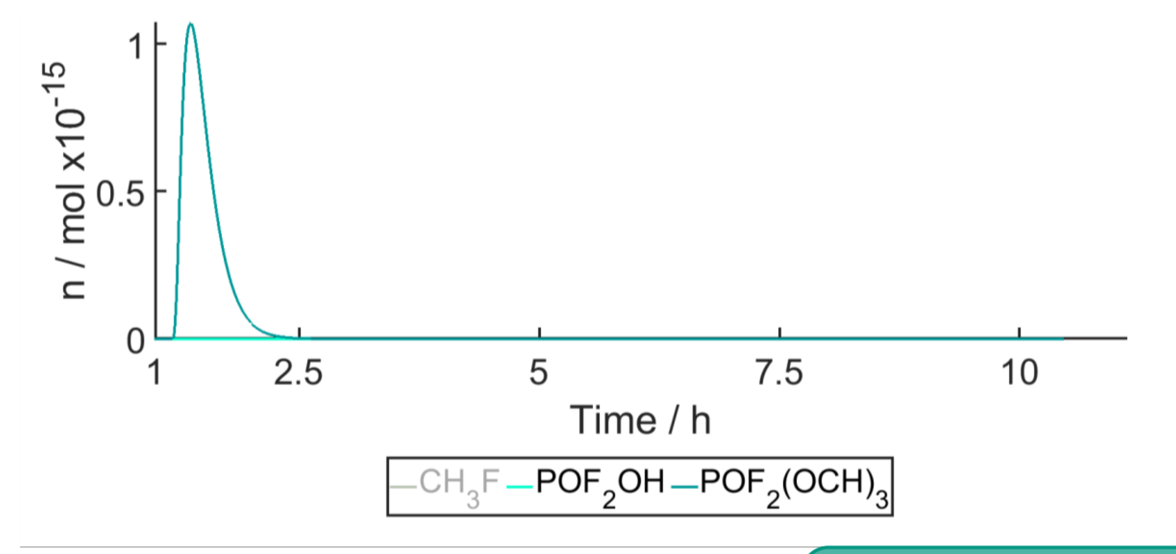
Dynamic Volume Impact

- No notable difference between static and dynamic volume

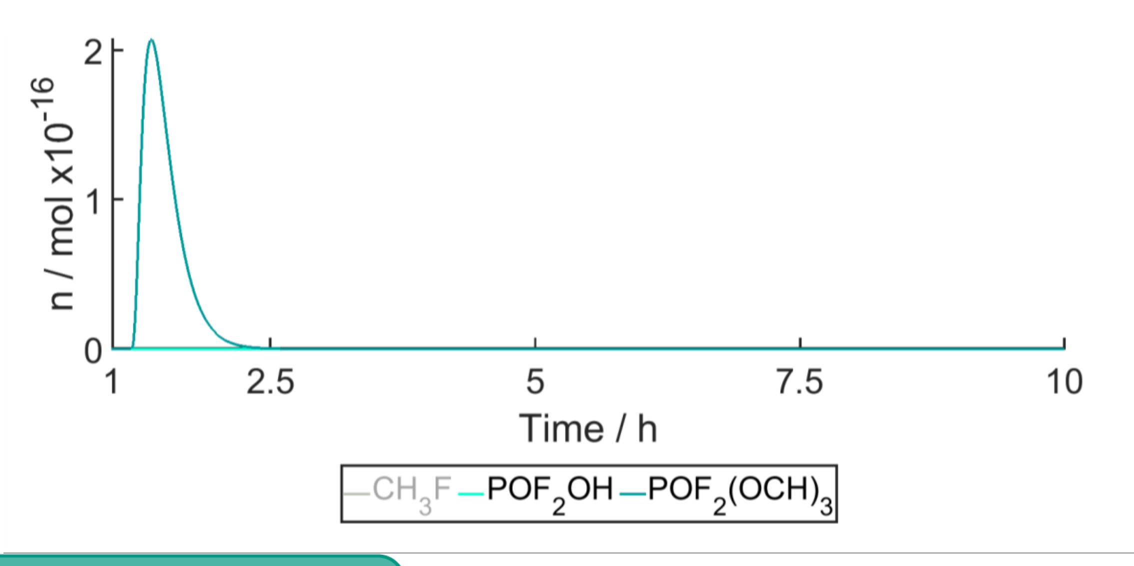
Dynamic Volume – Low Concentration Species







Dynamic Volume



Dynamic Volume Impact

- $POF_2(OCH)_3$ amount differs in one order of magnitude
- Diffusion coefficient for dynamic volume one order of magnitude lower than for static

Outlook



Improving the Model

- Finding the cause for decrease in concentration in diffusion model
- Adapting boundary conditions
- Finding workable diffusion coefficient ranges

Further Implementations

- Implementing Lithium Diffusion between Anode and SEI
- Allowing for electrochemical reactions to take place
- Adding gas volumes to dynamic volume

Experimental Comparison

- Comparing experimental to simulated results
- Check for differences in electrolyte species



Thank you for your attention!

diffusion out of simulated area

Li_xC6 bulk

Anode particle

SEI

Electrolyte

Electr. bulk

Diffusion – impact on simulation



Species development over time for all VE

n / mol x10^{-6}

1.5
1
0.5
0

0 0.5 1 1.5 2 2.5 3 3.5 4

Time / s

$\times 10^4$

$LiPF_6$ DMC EC

Diffusion – impact on simulation



Species development over time for all VE

n / mol x10^{-8} (0 – 3) vs. Time / h (0 – 10)

Legend: LiOH, C_2H_4, CO, CO_2, H_2O, HF, O_2, PF_5, POF_3, CH_3F, POF_2OH, $POF_2(OCH)_3$

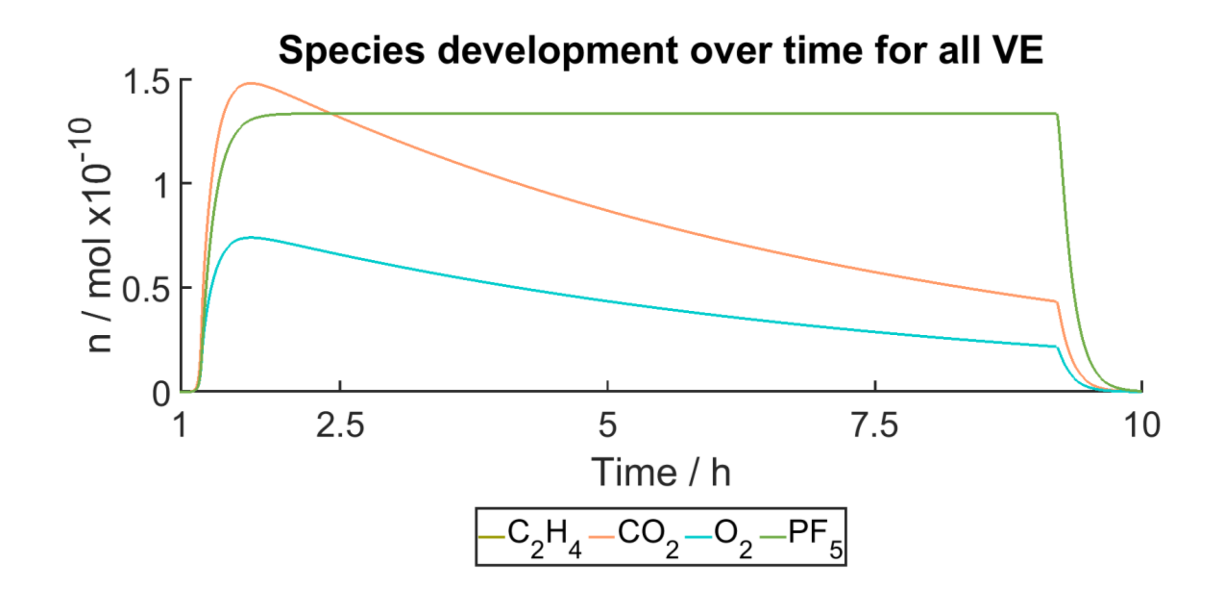
OPH02: $$PF_5 + H_2O_{(l)} \rightleftharpoons POF_3 + 2\,HF \quad (15)$$

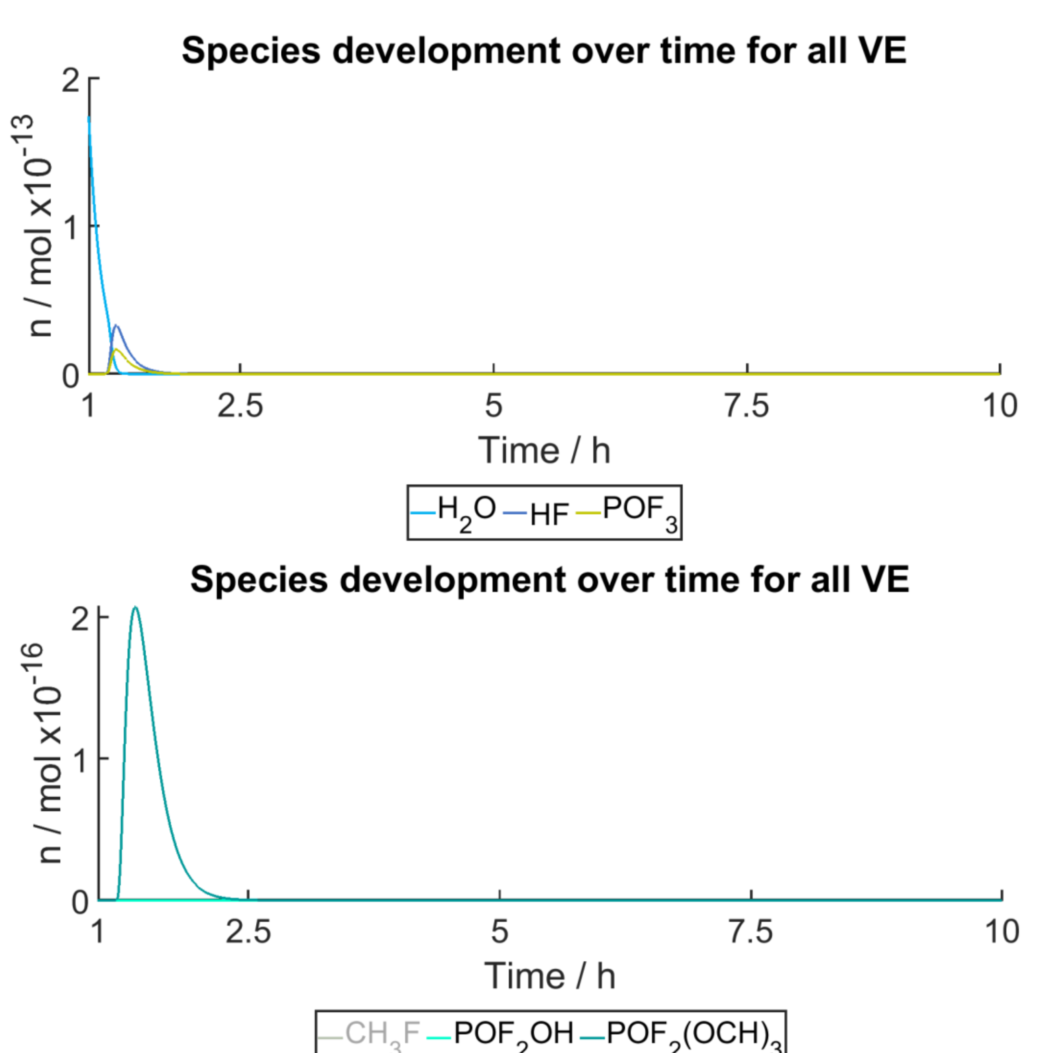
OPH03: $$POF_3 + H_2O_{(l)} \rightleftharpoons POF_2OH + 2\,HF \quad (16)$$

OPH06: $$POF_3 + DMC \rightleftharpoons POF_2OCH_3 + FCH_{3(g)} + CO_{2(g)} \quad (17)$$

Diffusion – impact on simulation

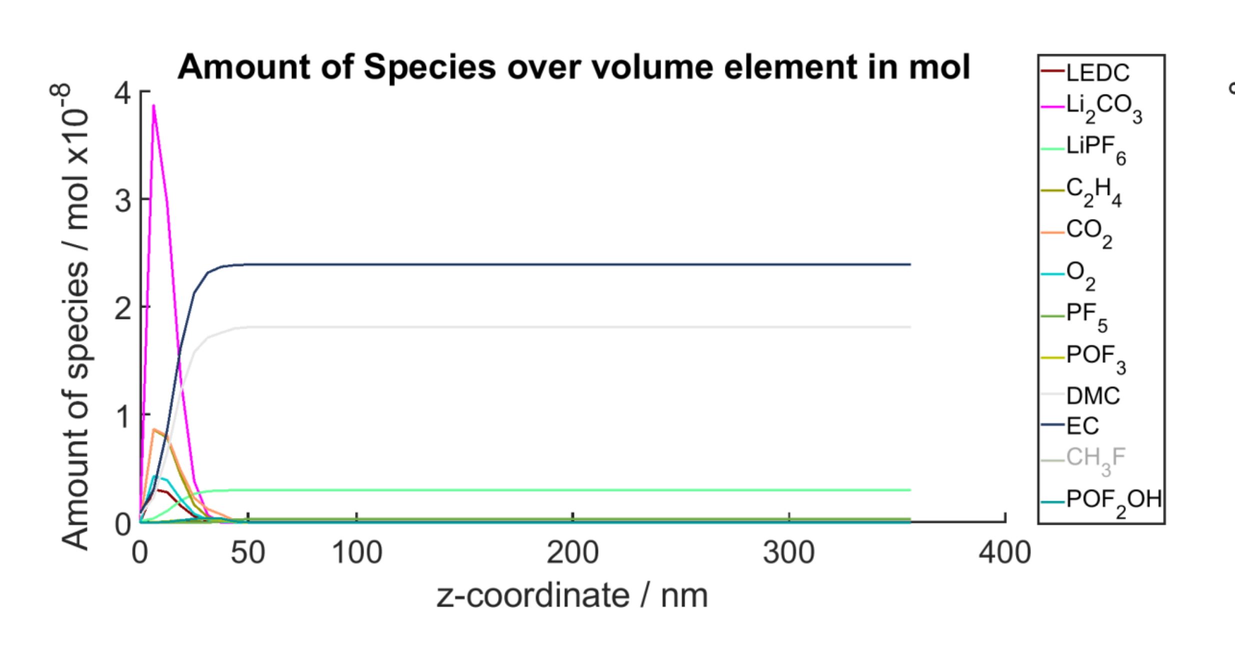


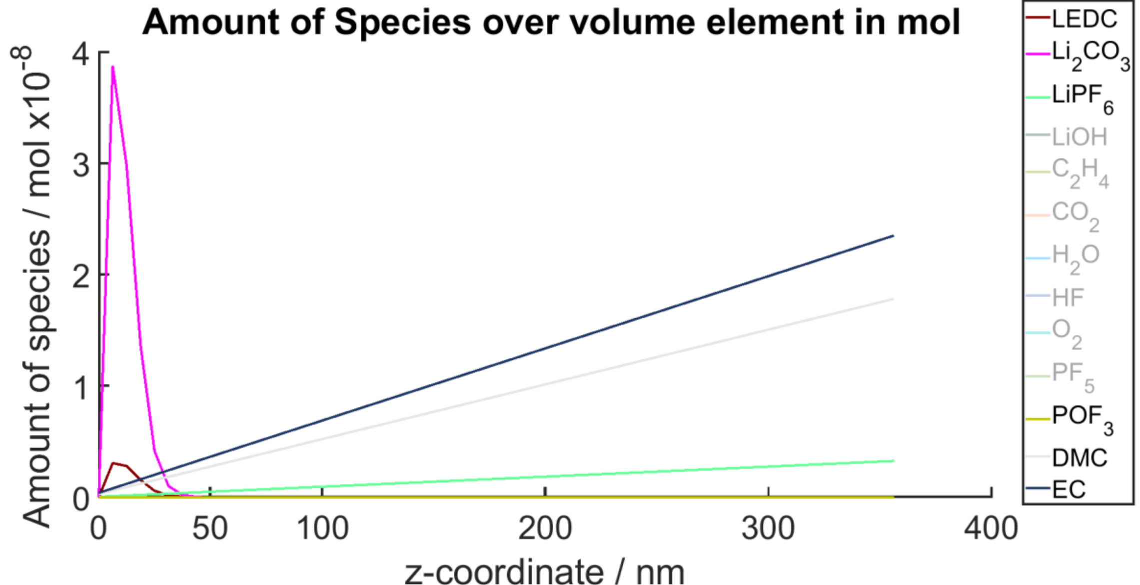




Diffusion – impact on simulation







Dynamic volume – impact on simulation



Differential length of volume unit from t=0 to t=end

dx / nm

0 0.5 1 1.5 2

0 10 20 30 40 50 60 70 80

volume unit / #

Reaction Parameters



UNT01: $$\mathrm{LEDC} \rightleftharpoons \mathrm{Li_2\,CO_3} + \mathrm{C_2H_4}_{(g)} + \mathrm{CO_2}_{(g)} + 0.5\ \mathrm{O_2}_{(g)} \quad (12)$$

HFWD06: $$\mathrm{Li_2\,CO_3} + 2\ \mathrm{HF} \rightleftharpoons 2\ \mathrm{LiF}_{(s)} + \mathrm{CO_2}_{(g)} + \mathrm{H_2O}_{(l)} \quad (13)$$

SAL01: $$\mathrm{LiPF_6}_{(s)} \rightleftharpoons \mathrm{LiF}_{(s)} + \mathrm{PF_5} \quad (14)$$

OPH02: $$\mathrm{PF_5} + \mathrm{H_2O}_{(l)} \rightleftharpoons \mathrm{POF_3} + 2\ \mathrm{HF} \quad (15)$$

OPH03: $$\mathrm{POF_3} + \mathrm{H_2O}_{(l)} \rightleftharpoons \mathrm{POF_2OH} + 2\ \mathrm{HF} \quad (16)$$

OPH06: $$\mathrm{POF_3} + \mathrm{DMC} \rightleftharpoons \mathrm{POF_2OCH_3} + \mathrm{FCH_3}_{(g)} + \mathrm{CO_2}_{(g)} \quad (17)$$

Reaktionsbezeichnung	Aktivierungsenergie E_A [J/mol]	Geschwindigkeitskonstante k
EC01	$2 \cdot 10^5$	$1 \cdot 10^{13}$
EC02	$1{,}2 \cdot 10^5$	$1 \cdot 10^{13}$
EC03	$3 \cdot 10^5$	$1 \cdot 10^{13}$
DMC01	$1 \cdot 10^9$	0
DMC02	$1 \cdot 10^9$	0
IMP06	$2 \cdot 10^5$	$1 \cdot 10^{13}$
IMP07	$1 \cdot 10^6$	$1 \cdot 10^{13}$
IMP09	$2 \cdot 10^5$	$1 \cdot 10^{13}$
IMP10	$2 \cdot 10^5$	$1 \cdot 10^{13}$
UNT01	$1{,}77 \cdot 10^5$	$1 \cdot 10^{13}$
HFWD06	$1{,}1 \cdot 10^5$	$1 \cdot 10^{13}$
SAL01	$1{,}81 \cdot 10^5$	$1 \cdot 10^{13}$
OPH02	$1{,}38 \cdot 10^5$	$1 \cdot 10^{13}$
OPH03	$2 \cdot 10^5$	$1 \cdot 10^{13}$
OPH06	$1{,}8 \cdot 10^5$	$1 \cdot 10^{13}$

WS R3DT GmbH | Aufgaben

Aufgabengebiete

- Technische Dokumentation der Software
- Aufbau einer Knowledge Base für Entwicklung und Kunden
- Qualitätssicherung
- Kundenbetreuung
    - technischer Support
    - Installation
    - Softwarepräsentation
- Konzeptionelle und operative Begleitung neuer Softwarefeatures und -releases

Aufgabengebiet

- Dokumentation
- Aufbau Testszenarien/-prozesse
- Strukturierung QA
- Meetings mit Kunden (digital und vor Ort)
- Erstellung Graphiken, Webdesign
- Erstellung Videoinhalte
- Mitarbeit Cloud Security Prüfungen
- Konzept und Vermittlung Feature Integration

WS R3DT GmbH | Knowledge Base

XREASY Knowledge Base FAQ Support anfordern EN Log in

Sie schaffen das, wir helfen Ihnen!

Search



Quick Guide

Der schnellste Weg zu XR-EASY.

Zum Quick Guide



Handbuch

Dieses Handbuch hilft beim Einrichten und Kennenlernen der VR-Software XR-EASY®.

Zum Handbuch



FAQ

Häufig gestellte Fragen von Produktinformationen, über Bedienung bis zur Fehlerbehebung.

Zur FAQ



Support

Schreiben Sie uns eine E-Mail. Wir helfen Ihnen!

Zum Support



Cloud Support

Alles über die Einrichtung der XR-EASY Cloud durch IT-Personal.

Zum IT Support

WS R3DT GmbH | Konzepte

Hand Menu variants

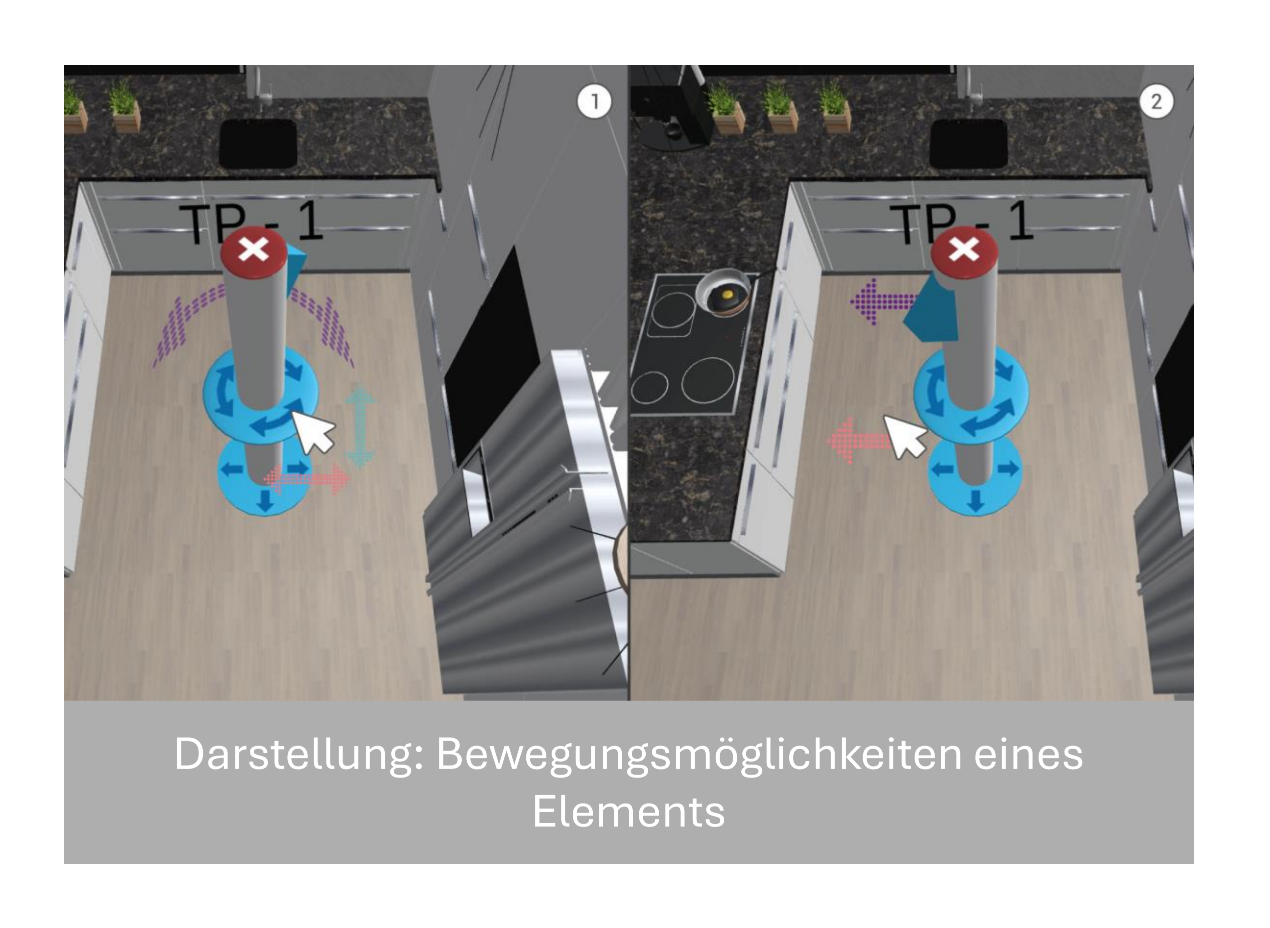
- VARIANT
- MENUS
- BUTTONS
- CODE - B-Button, M-Menu

Variant	Functions
M1 // SA HOST NO WORK	MOVEALL B57 TELEPORT M3 | 0 SESSION M11
M2 // PC VR NO WORK HOST	TELEPORT M3 | 0 GENERAL TOOLS M4 SESSION M11
M3 // SA NO WORK HOST	MOVEALL B57 TELEPORT M3 | 0 MEASUREMENT B20 SESSION M11
M4 // SA + PC VR WORK PERM HOST + JOIN	WORKVR B49 TELEPORT M3 | 0 SESSION M11
M5 // PC VR WORK ON HOST + JOIN	TELEPORT M3 | 1 OBJECT TOOLS M5 GENERAL TOOLS M4 MODULES M6 SESSION M11
M6 // SA WORK ON HOST + JOIN	TELEPORT M3 | 1 OBJECT TOOLS M5 MEASUREMENT B20 MODULES M6 SESSION M11
M7 // SA JOIN NO WORK	TELEPORT M3 | 0 SESSION M11

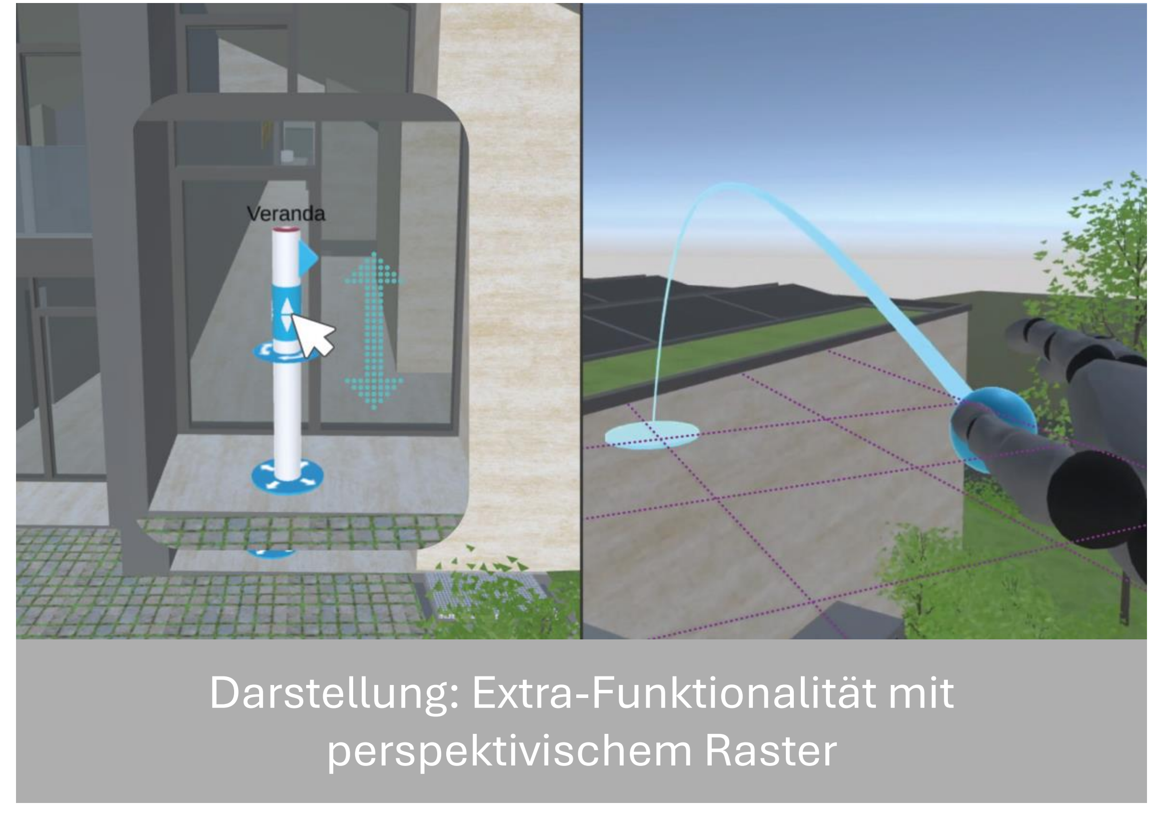
Permission Level VR - Menus

	Free			Licensed		
	PC VR	StandAlone (SA)	StandAlone Studio	PC VR - Pro	PC VR - Studio	PC VR - Showroom
Offline	M2 // PC VR NO WORK HOST	M3 // SA NO WORK HOST	M3 // SA NO WORK HOST	M5 // PC VR WORK ON HOST	M3 // SA NO WORK HOST	M6 // SA WORK ON HOST
	TELEPORT M3 | 0 GENERAL TOOLS M4 SESSION M11	MOVEALL B57 TELEPORT M3 | 0 MEASUREMENT B20 SESSION M11	MOVEALL B57 TELEPORT M3 | 0 MEASUREMENT B20 SESSION M11	TELEPORT M3 | 1 OBJECT TOOLS M5 GENERAL TOOLS M4 MODULES M6 SESSION M11	MOVEALL B57 TELEPORT M3 | 0 MEASUREMENT B20 SESSION M11	TELEPORT M3 | 1 OBJECT TOOLS M5 MEASUREMENT B20 MODULES M6 SESSION M11
COOP-Host: Work	M2 // PC VR NO WORK HOST	M3 // SA NO WORK HOST	M3 // SA NO WORK HOST	M5 // PC VR WORK ON HOST	M1 // SA NO WORK HOST	M6 // SA WORK ON HOST
	TELEPORT M3 | 0 GENERAL TOOLS M4 SESSION M11	MOVEALL B57 TELEPORT M3 | 0 MEASUREMENT B20 SESSION M11 Notes: • If you host as SA user, you cannot give permission	MOVEALL B57 TELEPORT M3 | 0 MEASUREMENT B20 SESSION M11 Notes: • If you host as SA user, you cannot give permission	TELEPORT M3 | 1 OBJECT TOOLS M5 GENERAL TOOLS M4 MODULES M6 SESSION M11	MOVEALL B57 TELEPORT M3 | 0 SESSION M11	TELEPORT M3 | 1 OBJECT TOOLS M5 MEASUREMENT B20 MODULES M6 SESSION M11
COOP-Host: Viewer	M2 // PC VR NO WORK HOST	M3 // SA NO WORK HOST		M4 // PC VR WORK PERM HOST	M1 // SA NO WORK HOST	M4 // SA WORK PERM HOST
	TELEPORT M3 | 0 GENERAL TOOLS M4 SESSION M11 Notes: - If you host as license free user, you cannot give nor take permission			WORKVR B49 TELEPORT M3 | 0 SESSION M11		WORKVR B49 TELEPORT M3 | 0 SESSION M11
COOP-Join: Work	M5 // PC VR WORK ON JOIN	M6 // SA WORK ON JOIN		M5 // PC VR WORK ON JOIN	M1 // SA NO WORK JOIN	M6 // SA WORK ON JOIN
	TELEPORT M3 | 1 OBJECT TOOLS M5 GENERAL TOOLS M4	TELEPORT M3 | 1 OBJECT TOOLS M5 MEASUREMENT B20		TELEPORT M3 | 1 OBJECT TOOLS M5 GENERAL TOOLS M4		TELEPORT M3 | 1 OBJECT TOOLS M5 MEASUREMENT B20

WS R3DT GmbH | Graphik



Darstellung: Bewegungsmöglichkeiten eines Elements



Darstellung: Extra-Funktionalität mit perspektivischem Raster